FOOD MONITORING SYSTEM FOR MONITORING FOOD LOCATED AT FOOD SERVING OR STORAGE LOCATIONS

Field of the Invention:

5   The present invention relates to monitoring systems in

general and in particular to a monitoring system for

monitoring food located at food serving or storage locations.

Background of the Invention:

Buffet style restaurant facilities and cafeterias

10   commonly contain food in temperature controlled serving

containers. Some facilities contain several food service

containers, each container being adapted to maintain a certain

food product within a certain temperature range for several

hours at a time. If food is not maintained within a

15   predetermined temperature range then food can lose its flavor.

More importantly, food spoilage can ensue if food which should

be kept at cool temperatures becomes too warm or if food which

should be kept at warmer temperatures becomes too cool.

Because of the number of injuries which could result from

20   food spoilage, large scale food serving facilities expend a

vast amount of resources in assuring that food temperature is

maintained properly.

Many large scale food service facilities employ

inspectors who record food temperature using a specially

25   designed portable data collection device adapted to collect

temperature data from served food. In use of such devices, an

inspector places the device in contact with a served food

product to record food temperature. One portable data

collection device is used to collect data from each of several

5   food product containers. Records over time for various

serving or storage containers are kept manually, or, in more

sophisticated devices are uploaded from a data collection

device at intervals determined by the inspector, to a central

processing facility.

10   Monitoring methods involving use of a portable data

collection device are time consuming and require an excessive

amount of human labor to be effective. Since these methods

require human labor they are also susceptible to failure

resulting from human error in the data collection process.

15   While human error and labor costs always limit the

reliability and cost effectiveness of monitoring methods that

require human labor, such as those methods involving use of a

portable data collection devices, methods in which data is

uploaded into computer storage devices are the susceptible to

20   another type of problem. Food monitoring systems in which

data is stored in host computers have been observed to be

susceptible to tampering schemes which would allow an

unscrupulous data collection worker to alter data recorded in

a computer memory to cover up a system operations problem in the event an operations problem is observed.

There is a need for a food monitoring system which accurately monitors the temperature of stored or served food without requiring substantial human labor for effective operation, and which is substantially impervious to data tampering.

Summary of the Invention:

According to its major aspects and broadly stated the present invention is a food monitoring system for use by food service facilities which provides automatic monitoring and recording of data pertaining to food located at several food service or food storage locations. A data processing method associated with the method includes a provision that prevents unscrupulous tampering of stored data.

A monitoring system according to the invention includes a sensing subsystem and a processing subsystem. The sensing subsystem includes at least one sensing device and a transmitter while the processing subsystem normally includes a receiver and personal computer for recording and outputting sensed data. Sensing devices of the sensing subsystem may be in utensil form or in a simplified probe form.

A simplified probe structure for a sensing device

comprises a rigid cylindrical housing and an elongated hollow

pin section extending from the housing. In this simple

structure a sensor can be completely disposed within a pin

section enclosure to completely encapsulate the sensor. This

5   simple structure provides the advantage of making the device

easy to clean. Because simplified probe sensing devices do

not have to be repeatedly removed from food, several probes

can be hard-wired to a single multiprobe transmitter which

transmits data from each of several probes to a receiver of

10   the processing subsystem.

Signal processing circuits of the sensing devices receive

sensor signals from at least one sensor and assemble digital

data bitstreams for transmission to the processing subsystem.

In addition to processing signals from at least one sensor,

15   the signal processing circuits of the sensing devices

preferably generate bitstream data that encodes a device

identifier encoding the identification of the device

generating the data.

Data received by the processing subsystem is processed in

20   accordance with instructions of a main program stored in a

memory device. According to a typical processing routine, a

processor compresses bitstream data, date and time stamps the

data, and writes the bitstream data to a file of a memory

device comprising an indexed hierarchical data storage

structure adapted facilitate fast reading of data from memory.

To the end that data written to memory cannot readily be

altered or otherwise corrupted, the processor subsystem

5   preferably encrypts sensor bitstream data according to an

encryption scheme when writing the data to memory. Use of an

encryption scheme which cannot be determined without access to

the main program's source code substantially prevents

tampering of data stored in memory.

10   In a preferred embodiment, the processor is programmed

with use of a sophisticated programming language facilitating

graphical display of data which allows data to be observed in

a variety of useful ways. The processor is preferably

configured to survey all devices currently connected to the

15   system, and to view sensor and battery data over time for any

device which has been connected to the system, for any time

period in which the system has been in use.

These and other details, advantages and benefits of the

present invention will become apparent from the detailed

20   description of the preferred embodiment herein below.

Brief description of the Drawings:

In the drawings, wherein like numerals are used to indicate the same elements throughout the views,

Fig. 1A is a physical schematic diagram of an exemplary embodiment of a system according to the invention;

Fig. 1B is a physical embodiment of probe sensing device which may be used in connection with the invention;

Fig. 2 is an exemplary block electrical diagram of an exemplary electrical system of the invention;

Fig. 3 is a diagram illustrating an exemplary data bitstream format which may be generated by a sensing device the invention;

Fig. 4 is a flow diagram illustrating an exemplary operation of a data processing method of the invention;

Fig. 5 illustrates an exemplary structure for a time and date stamped representative bitstream of the invention;

Fig. 6 illustrates a possible indexed hierarchical file structure allowing for quick retrieval of data stored by the system's processing subsystem;

Fig. 7 illustrates a first exemplary display output according to the invention;

Fig. 8 illustrates a second exemplary display output according to the invention.

Detailed Description:

A physical schematic diagram of the invention is shown in
Fig. 1A. System 10 includes sensing subsystem 12 for sensing
certain characteristics, most typically temperature

5 characteristics of at least one food product and processing
subsystem 14 for outputting and recording data received from
the sensing subsystem.

Sensing subsystem 12 includes at least one sensing
apparatus for sensing characteristics of food. In the

10 embodiment of Fig. 1A sensing subsystem 12 includes two types
of sensing devices for sensing characteristics of served food
contained in temperature controlled serving containers 16,
which are sometimes referred to as "warming trays". A first
type of sensing device for sensing characteristics of served

15 food is a cooking utensil 18 such as a spoon, fork, ladle, or
spatula while a second type of sensing device for sensing
characteristics of served food is a probe 20, 20', 20''. Both
cooking utensils 18 and probes 20 have at least one sensor,
typically a temperature sensor, disposed thereon for sensing

20 at least one characteristic of food. Utensils 18 and probes
20 are adapted to be disposed within a food product so that
the sensor of the sensing device is in an operational sensing
arrangement in relation to the food product. For example if

the sensing device includes a thermal sensor, then the device

is adapted so that the thermal sensor is in thermal contact

with food when disposed in contact therein. Sensing system 12

includes at least one sensing device such as a utensil or a

5   probe, but more typically will include a plurality of probes,

utensils, or combinations of probes and utensils for sensing

characteristics of food form several temperature controlled

serving containers 16. Sensing subsystem 12 further includes

a plurality of transmitters 22, 22', 24 for transmitting data

10   generated from the served food sensing devices to the

processing subsystem 14.

While the sensors incorporated in utensils 18 and probes

20 normally include temperature sensors, these devices may

also be adapted to include, in addition to or alternatively,

15   other types of sensors such as seismic sensors, pressure (psi)

sensors, airflow and weight sensors. Furthermore it will be

understood that in addition to having sensing devices for

sensing characteristics of served food such as utensils and

probes, sensing subsystem 12 may be adapted to include,

20   additionally or alternatively, permanent position sensing

devices, such as sensing device 13 for sensing temperature or

other characteristics of stored food or other stored material

or objects. In the embodiment of Fig. 1A, sensing device 13

is a thermocouple mounted in the interior of a refrigerator 15

which is in communication with a transmitter 17 for

transmitting data corresponding to signals generated by

thermocouple 13.

5   Processing subsystem 14, meanwhile, may comprise a

personal computer 25 as shown in Fig. 1A having a keyboard 26,

a mouse 27, a display 28, a processor 66, a memory 68 and a

receiver 30 for receiving data from transmitters 17, 22, 22',

24 of the sensor subsystem 12. Processing subsystem 14 may

10   also be provided, for example, by a programmable touch screen

in communication with a receiver.

A detailed physical schematic diagram of an exemplary

probe 20''' of subsystem 12 is shown in Fig. 1B. Probe 20'''

includes pin section 32 which is adapted for contact with a

15   food product and a housing section 34 which houses a printed

circuit board (PCB) 36 and a battery 37. For adapting probe

20''' to sense temperature, sensor or thermocouple 38 is

deposited in pin section 32 and is completely enclosed by pin

section 32. Thermocouple 38 may be provided by a type K

20   thermocouple wire. Temperature indicating signals generated

by thermocouple 38 are input to signal processing circuitry of

PCB 36 which processes the sensor signal in a manner that will

be described herein below.

While probes 20, 20', and 20'' are shown as being hard-wired to a central transmitter 24, probe 20''' of Fig. 1B includes a dedicated transmitter, similar to transmitter 22, having an associated antenna 40. Circuitry for the dedicated

5   transmitter of probe 20''' may be incorporated in PCB 36.

Probes of the type described, while they do not provide the function of being able to aid in the serving of food products, offer important advantages over sensing devices embodied in utensils, such as utensils 18 and 18'.

10   Probes are simpler in construction than utensil sensing devices, and therefore are more readily made in a configuration that enables them to be easily cleaned and sanitized. An important feature of the probe of the embodiment of Fig. 1B is that thermocouple 38 is disposed

15   entirely within pin section 32, and does not come in direct contact with food products. Utensil sensing devices, by contrast, are not easily made with a thermocouple that is completely enclosed and yet is adapted to be good thermal contact with food in which the utensil is disposed. The

20   National Sanitation Foundation (NSF), an independent not-for-profit organization tests utensils, devices, and tools, for use with food products, and approves them for use with food products only if they meet certain criteria for cleanability.

Especially since the design provides for an enclosed

thermocouple, probes of the general configuration described

are expected to readily satisfy these criteria.

The fact that probes do not have to be repeatedly

5   inserted into and removed from served food enables a plurality

of probes to be hard-wired via conductors 21, 21', 21'' to a

single transmitter 24, without substantively affecting the

functioning of the devices. By contrast, hard wiring of

utensil sensing devices 18, 18' to a central transmitter is

10   not generally viable given the requirement of mobility of such

devices. Utilization of a single transmitter 24 to service

several simply-constructed probes not intended to be regularly

removed from food significantly reduces the overall costs of

sensing subsystem 14.   To the end that conductors 21, 21', 22'

15   are minimally obtrusive to a food service agent serving food,

conductors 21, 21', 22'' may comprise flattened conductor

housings and may be fixedly adhered to or otherwise secured to

at least one surface in proximity with containers 16, such as

surfaces 29, 31 of a member 33 that supports containers 16 as

20   is shown in Fig. 1A.

Additional operational aspects of system 10 are described

with reference to Fig. 2 showing an exemplary block electrical

diagram for sensing subsystem 12 and processing subsystem 14.

As indicated above, a distinction between utensil sensing

devices 18 and probe sensing devices 20 is that while a

plurality of probes 20 can be serviced by a single transmitter

24, each utensil sensing device normally is serviced by a

5 dedicated transmitter 22, 22', the circuitry of which is

incorporated in utensil handle 23, 23'. Aside from this

distinction, utensils and probes 20 have similar electrical

configurations.

In a typical embodiment, each sensing device includes a

10 signal processing circuit 46 powered by battery 37 for

processing signals from at least one sensor of the device.

Normally, the at least one sensor of each device will include

a temperature sensor 18. In addition to receiving signals

from a temperature sensor 38, signal processing circuit 46

15 receives signals from battery 37 indicating a voltage level

thereof.

In the exemplary embodiment, the signal processing

circuit 46 of each device develops a multi-character digital

bitstream 50 as represented in Fig. 3 encoding data generated

20 by that device, for transmission to processing subsystem 14.

Bitstream 50 may include a first set of bits 52 encoding a

preamble for the data transmission (a set of bits indicating

the following bits encode valid data), a second set of bits 54

indicating the temperature reading from temperature sensor 38,

a third set of bits indicating the voltage level of battery

37. In addition to including sets of bits that include sensor

data and battery level data, bitstream 50 may also include

5   sets of bits identifying the particular sensing device

generating the data. Accordingly, each signal processing

circuit 46 should include circuit elements generating

identification stamps indicating the device originating the

data. Circuit 46 may include circuit elements which generate

10   at least two identification stamps, in the form of bit sets of

bitstream 50, for each device. To the end a data bitstream

encodes an identifier of the device generating the bitstream,

a fourth set of bits 58 of bitstream 50 may encode the device

type (i.e spoon, fork, ladle, spatula, probe) of the device,

15   while a fifth set of bits 60 of bitstream 50 may encode a

specific device identifier. A sixth set of bits 62 of

bitstream generated by circuit 46 should include a postamble

indicating an end of valid data transmission. Since circuit

elements for conversion of analog data from sensor 38 and

20   battery 37 and generating a bitstream of data therefrom, and

for generating identification bit sets are well known, they

will not be described further herein.

Signal processing circuit 46 sends data via a conductor

to a transmitter 22 which in the case of utensil sensor device

is typically a transmitter dedicated for that utensil, and in

the case of probe sensor a central transmitter 24 that

5   services a plurality of probes.

Bitstream data which is transmitted by transmitters is

received by the processing subsystem 14, which in addition to

including a receiver 64 for receiving the transmitted data,

may include the elements of a microprocessor 66 which

10   communicates with receiver 64 via an I/O port (not shown), an

associated memory 68 (typically including such memory devices

as a program memory device, a RAM and a long term storage unit

such as a hard drive), a display device 28, and input devices

such as a keyboard 26 and mouse 27. When processing subsystem

15   14 includes a standard microprocessor, receiver 64 is adapted

to convert received bitstream data into a format enabling the

data to be processed by microprocessor 66, such as an RS 232

format.

Transmitters 17, 22, 22', 24, of the sensor subsystem 12

20   and receiver 64 of the processing subsystem 14 are preferably

provided by RF transmitter and receiver units. However, it

will be understood that the transmitters and receiver could be

replaced by other wireless communication devices, such as a

group of infrared transmitters and an infrared receiver or other types of hard-wired communication structures such as a multiplexed cable arrangement, a LAN, or an ethernet.

Data generated by the various sensor elements 37, 38 of sensor subsystem 12 normally does not have to be sampled at an extremely high sample rate. Although data from the various sensing elements could be sampled at virtually any sample rate from an ultrafast submicrosecond sampling rate to a slower sample rate of once per several minutes, it is normally sufficient to configure system 10 to sample data at a rate that ranges from about once per several seconds to once per several minutes. Typically, system 10 is configured to sample data from each device 18, 20 at a sampling rate of about one sample per minute. Because the data generated by the various devices 18, 20 does not have to be sampled at an extremely high data rate, and the occurrences of collisions between samples are correspondingly rare, it is normally not necessary to establish a high degree of coordination between the receiver 64 and the transmitters 17, 22, 22', 24 of subsystem 12. Accordingly, operable communication between transmitters 22, 22', 24 and receiver 64 can normally be established by configuring transmitters 22, 22' to send bitstream samples generated by their associated sensor device at a rate of about

once per minute, and configuring transmitter 24 so that

transmitter 24 transmits samples received at each of its input

ports at a rate of about one sample per minute. A sample

period should be long enough so that at least one complete

5   bitstream 50 as described with reference to Fig. 3 is assured

of being included in each sample. Preferably, a sample period

is configured so that each sample contains a plurality of data

bitstreams.

Referring now to the flow diagram of Fig. 4, an exemplary

10   method by which processor 66, operating under control of a

main program stored in memory 68, may process data samples

received by processing subsystem 14 will be explained in

detail.

In an exemplary embodiment described in connection with

15   the flow diagram of Fig. 4, processor 66 receives a sample at

block 68, which as explained previously typically includes

several bitstreams of the general configuration of data

bitstream 50 and at block 70 executes a simple compression

algorithm to compress the sample bitstream data to a form a

20   single representative bitstream. This simple compression

algorithm may comprise, for example, selection of one

bitstream out of the several bitstreams, or averaging of data

encoded in all or several of the bitstreams of a sample.

After constructing a representative bitstream, processor 66 at

block 72 stamps the bitstream with date and time stamps (with

year/month/day/time information). When date and time stamping

is complete, representative bitstream 78 as shown in Fig. 5

5   will include sets of bits, e.g. 80, 82, corresponding to the

date and time stamps in addition to those bit sets 52, 54, 56,

58, 60, 62 encoding the parameters of the original bitstream

50.

      To facilitate fast and efficient retrieval of data stored

10   in memory 68, memory 68 may include files comprising

preconfigured indexed hierarchical data storage structures for

arranging data pertaining to specific sensing device in a

systematic manner. A typical file structure for arranging

data in memory 68 so that data may be quickly and efficiently

15   retrieved is described with reference to Fig. 6. In a

preferred embodiment, memory 68 includes a file 84 for each

sensing subsystem such as subsystem 12 that processing

subsystem 14 is configured to monitor. Each file 84,

meanwhile, preferably includes a device index tree 85 for each

20   device such as devices 18, 20 included in subsystem 12.

Device trees 85, may include indexes 86, 88, 90, 92 pertaining

to a device identifier, a date stamp year, a date stamp month,

and a date stamp day, respectively. When processor 66 writes

data into memory 68, it writes data to a file and offset
location that depends on the identifier bit sets identifying
the device originating the data, and the year, month, and day
of the date stamp.

5   Before writing time and date stamped representative
bitstream 78 to memory 68, processor at block 73 determines
whether the present bitstream data pertains to a new sensing
device just added to system. If the data does pertain to a new
device, processor 66 at block 74 establishes a new device

10   index tree 85 dedicated for storing present and future data
pertaining to that particular device.

       After determining the appropriate file and offset
location for the bitstream data, processor at block 75 writes
the bitstream data to the determined appropriate file and

15   offset location. While writing data to memory 68, processor
66 preferably encrypts the bitstream data so that value or
values of the sensor data cannot be determined by inspection,
and cannot be determined without knowledge of the specific
encryption scheme used and/or without access to a decryption

20   scheme complementary with the employed encryption scheme.
Since the employed encryption scheme cannot be determined
without access to a high level program language readout of the
main program, encryption of data as its is written into memory

68 provides for security of data recordings. The encryption
of data written into memory 68 with a secret encryption scheme
known only to the software provider prevents an unscrupulous
computer records keeper from altering or tampering with stored

5   data in a meaningful and organized way, thereby improving the
reliability of computer-stored data. The encryption scheme
used may be any commercially available encryption scheme.
Encryption schemes which may be used with the present
invention are described, for example, in Bruce Schneier,

10   *Applied Cryptography,* Second Edition, John Wiley & Sons, 1996.

Before encrypting data and writing encrypted bitstream
data to preconfigured indexed data storage structures of
memory 68, processor 68 may drop those sets of bits from
bitstream 78 pertaining to the date stamp information (year,

15   month, day) in the interest of conserving memory space.
However, the security of the encryption may be improved by
maintaining the date stamp bits through the encryption
process.

In addition to encrypting data while writing data to

20   memory 68, processing subsystem 14 may be adapted to carry out
additional processing functions designed to improve the
integrity and security of the data transmission. For example,
receiver 30 may be configured to encode sets of bitstreams

received from transmitters 17, 22, 22', 24 with application of an available encoding scheme (known only to the software designer) before sending encoded data to processor 66. Processor, in turn, in such an embodiment of the invention,

5 would be adapted to decode the encoded sets of bitstreams according to a decoding scheme corresponding to the encoding scheme. Severable applicable encoding and decoding schemes are also described in Schneier's *Applied Cryptography*, referenced above.

10 In addition to processing received data according to the above described protocol, processing subsystem 14 is also programed to output and display stored data in a variety of ways so as to facilitate useful and informative data analysis. Preferably, the display and data output function of subsystem

15 14 is programmed with use of a modern high level programming language having sophisticated graphical output capabilities. A preferred programming language for use in programming data output functions of subsystem 14 is Visual C++ 6.0 of the type available from Microsoft corporation of Seattle, WA. Examples

20 of other languages highly suitable for use in programming data processing functions of subsystem 14 are Visual Basic, also available from Microsoft and JAVA available from Sun Microsystems of Santa Clara, CA.

In a first display feature that is described with reference to the graphical output display of Fig. 7, processor 66 is adapted to display at system overview display section 102 all sensing devices e.g. device 18 which have been

5   connected to system 10 and to highlight, with some form of indicia, those devices currently logging data. The indicia indicating a device currently logging data may be, for example, a blinking icon, or a different colored icon, or supplementary icon. To facilitate this display feature,

10   processor 66 may be made to periodically poll the contents of memory 68 to determine the identifier associated with each index tree and to analyze the last data entry entered for each device index tree 85 which has been configured in memory 68. If the time stamp of the last data entry is within a

15   predetermined time of the present time, then the device is determined to be currently logging data. In the specific example of display section 102 a probe such as probe 20 of subsystem 12 is designated as a tray of a set of "warming trays". The system corresponding to display section 102

20   includes at least two sensing devices, a utensil indicated by "Ladle1" 103, and a probe as indicated by "Tray2" 105. "Ladle1" is currently logging data as is indicated by logging icon 107, while the probe of "Tray2" is not logging data as is

indicated by the absence of icon 107. A determination as to

whether the system corresponding to display section 102

includes any forks, spatulas, or spoons can be made by

clicking on folder icons 109, 111, 113 pertaining to forks,

5   spatulas or spoons. Subsystem 14 may be programmed so that

clicking on these icons causes graphical display of all

respective forks, spatulas or spoons of the system 10.

In another display feature, processor 66 is adapted to

display the device identifier, device type and the current

10   output of the sensors associated with a particular device.

Display section 104 shows a device identifier 106 device type

108, a temperature sensor reading 110, and a battery level

reading 112 for two devices connected to an exemplary system.

In outputting data on a display screen 28, processor 66 reads

15   bitstream data that has been previously recorded in memory 68,

which as previously explained was encrypted when written to,

and thus in a form which does not allow the data values to be

determined without application of a decryption scheme

associated with the scheme for encryption. Accordingly,

20   whenever processor 66 reads data from memory 68 for display,

it applies an appropriate decryption scheme to decipher the

data before displaying the data on screen 28. Current device

sensor values may be obtained by polling the contents of the

last data entry for each device that has been determined to be

currently connected to system.

A feature which may be implemented in connection with the

feature of displaying current sensor outputs is an alarm

5 feature. For example, if the temperature for a sensing device

is not within an acceptable range or if battery power falls

below an acceptable limit, then display 28 may be made to

generate an indicia indicating an alarm condition. Such

indicia may be graphical or audible.

10 In still another display feature, processor 66 is adapted

to display the status of any device which is currently

connected to or at one time was connected to system 10 as is

illustrated by display section 116. Processor 66 may be

configured so that any particular icon of system overview

15 display section 102 may be clicked on via mouse 27 to display

detailed information about the device corresponding to that

particular icon. In addition to displaying such data as a

device type 118, identification code 120, and the logging/not

logging status 122 of a device, status section 116 may also

20 display a detailed device description 124 including a text

message providing detailed information about the device. A

detailed device description may be displayed by accessing a

previously established lookup table correlating a device

identifier with device description associated with the device.

In yet another display feature, processor 66 is adapted to display sensor data over time for any device or collection of devices of system 10, at any time frame in the history of the operation of system 10. If the icon 130 labeled "history"
5   is clicked on, a user may be prompted to enter data pertaining to a time period of interest. In accordance with the entered time period, processor 66 may read contents from memory 68 for all devices logging data in that time period, or of select devices only, decrypt the data by application of an
10   appropriate decryption scheme, and cause display of the results on screen 28. The output of such data may be in tabular form or in graphical form as illustrated by graphical display 132 of Fig. 8 illustrating an output from a plurality of logging sensors in a selected time period of interest.
15   While this invention has been described in detail with reference to a preferred embodiment, it should be appreciated that the present invention is not limited to that precise embodiment. Rather, in view of the present disclosure which describes the best mode for practicing the invention, many
20   modifications and variations would present themselves to those skilled in the art without departing from the scope and spirit of this invention, as defined in the following claims.